U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-298 479

Comment on 'A Model for Total Phosphorus in Saginaw Bay'

(U.S.) Environmental Research Lab -Duluth, Grosse Ile, MI

1978

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. R
EPA-600/J-78-114	JOURNAL ARTICLE	PB 298479

4. TITLE AND SUBTITLE	5. REPORT DATE
Comment on "A Model for Total Phosphorus in Saginaw Bay"	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
David M. Dolan and Victor J. Bierman, Jr.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Large Lakes Research Station 9311 Groh Road Grosse Ile, Michigan 48138	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same as above	13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE EPA-600/03

15. SUPPLEMENTARY NOTES REFERENCE: Dolan, David M., and Victor J. Bierman, Jr. 1978. Comment on "A Model for Total Phosphorus in Saginaw Bay". J. Great Lakes Res., Internat. Assoc. Great Lakes Res. 4(1): 110-113.

16. ABSTRACT

The subject paper (Canale and Squire 1976) presents the results of the application of a steady-state mass balance model to chloride and total phosphorus data for Saginaw Bay in 1974. Richardson (1974, 1976) has modeled chloride in Saginaw Bay on both a steady-state and a time variable basis. In this work, the steady-state model was shown to be inadequate for this system, except during stable periods in summer and fall. Since most of the loading of pollutants to the bay does not occur at these times, the time variable model was developed. The purpose of this comment is to compare similar aspects of these projects and to contrast the steady-state and time variable approaches with respect to their ability to simulate observed phenomena and the utility of their results.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Limnology Aquatic chemistry	Modeling Phosphorus	08/H

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	4
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	A02 - A01

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

EPA-600/J-78-114
JOURNAL ARTICLE

J. Great Lakes Res., March 1978
Internat. Assoc. Great Lakes Res. 4(1):110-113

COMMENT ON "A MODEL FOR TOTAL PHOSPHORUS IN SAGINAW BAY"

David M. Dolan
and
Victor J. Bierman, Jr.
Environmental Protection Agency
Large Lakes Research Station
Grosse Ile, Michigan 48138

ABSTRACT. The subject paper (Canale and Squire 1976) presents the results of the application of a steady-state mass balance model to chloride and total phosphorus data for Saginaw Bay in 1974. Richardson (1974, 1976) has modeled chloride in Saginaw Bay on both a steady-state and a time variable basis. In this work, the steady-state model was shown to be inadequate for this system, except during stable periods in summer and fall. Since most of the loading of pollutants to the bay does not occur at these times, the time variable model was developed. The purpose of this comment is to compare similar aspects of these projects and to contrast the steady-state and time variable approaches with respect to their ability to simulate observed phenomena and the utility of their results.

BACKGROUND

Since the mid-sixties, EPA and its predecessor agencies have been interested in chloride as a pollutant loaded to Saginaw Bay from the Saginaw River. This loading has decreased from an annual average of 2.5 million Kg/day in 1965 to 0.76 million Kg/day in 1976 which, as a result, has decreased the importance of chloride as a pollutant in this system. At present, the main benefit of chloride modeling on this system is that inferences can be made about water movements and material dispersions. In addition, through careful observation of chloride gradients, useful spatial divisions have been made in the bay for purposes of interpreting other, more complex, water quality data.

LOADINGS

It is of interest to compare the loading presented in Table 1 of the subject paper to those calculated for 1974 by the Large Lakes Research Station (LLRS) of the Environmental Protection Agency. The annual average total phosphorus load of 1.06×10^{10} mg PO_4 per day agrees to 3 significant figures with that calculated by LLRS. The annual average chloride load of 9.73×10^8 g/day is within 9% of the LLRS load of 8.92×10^8 g/day. This agreement is remarkably good considering the use of different data sets and different methods of calculation.

DISPERSION

The dispersion coefficients among model segments in the subject paper were calculated from a fine-grid numerical circulation model of Saginaw Bay (Allender and Green 1976). The dispersion coefficients used by Richardson were inferred from observation of chloride gradients. In spite of the differences in approach, the numerical values used for the coefficients compare favorably. Canale's and Squire's values range from 2×10^2 to 5×10^5 $cm^2/sec.$, while Richardson's range from 2.9×10^5 to 18.5×10^5 cm^2/sec. The difference can be explained by the latter's larger grid size which results in local water movements of larger magnitude.

CHLORIDE CONTOURS

Figure 5 in the subject paper can be compared with Figure 5.10 from Richardson (1976). Canale and Squire (1976) present a September and a November calculated chloride profile, while Richardson's is an averaged July to November profile. Both calculated contours agree quite well with measured chloride values, and these contours agree qualitatively with each other. The intrusion of low-chloride water into inner Saginaw Bay from Lake Huron is probably better described by Canale and Squire (1976). Again, this may be partly due to grid size.

STEADY-STATE VS. TIME VARIABLE APPROACH

Chloride modeling on Saginaw Bay has continued at LLRS each year since 1974 for the purpose of supplying circulation information to our eutrophication models. The complex interactions among phytoplankton, zooplankton and nutrients in Saginaw Bay cannot be described with steady-state circulation patterns. In addition, the large seasonal variations in chloride loading will result in a failure of the steady-state approach to simulate chloride patterns (Richardson 1976). The steady-state results are approximately correct only during the second half of the year. As can be seen from Figure 2 in the subject paper, there is a marked difference in the variability of chloride loading in the first half of 1974 as compared to the second half.

Since chloride concentrations in the bay respond rapidly (on the order of days), to external loads and wind induced shifts in flow patterns (Allender and Green 1976), the solution technique employed for the mass balance must allow for changes in concentration with time. The time variable approach provides calculated concentrations of material each day in response to changes in loading and water movements. These calculated concentrations at a given time can then be compared with observed data for the same time. Therefore, while our basic modeling framework is the same as that used in the subject paper, the change of concentration with time is not constrained to equal zero.

The utility of the steady-state approach is questionable. In order to apply this type of model to Saginaw Bay, the conditions of near constant loading and steady winds both before and during the time period of interest must be met. The resultant time periods that could be simulated in this manner would be few and would be confined largely to the summer and fall. For phosphorus modeling this situation is unacceptable, since nearly 80% of the phosphorus loading occurs in the first half of the year, as is indicated by Figure 3 in the subject paper.

USE OF HYDRODYNAMIC MODELS

At LLRS, we are extending the use of hydrodynamic models in specifying water movements to a water quality model on a time variable basis. In a manner similar to that employed in this paper, the hydrodynamic model output is averaged over space and time to provide information to the course grid water quality model. A documented version of our time variable chloride model with an option for coupling to a hydrodynamic model is being developed.

In conclusion, many aspects of the subject paper and the LLRS program on Saginaw Bay are similar and compare well. However, we feel it is necessary to extend this modeling approach to dynamic descriptions of circulation so that complex, seasonal phenomena can be simulated. Our experience with Saginaw Bay has shown that the steady-state approach is not adequate for describing observed conditions throughout the year. The small additional effort required to solve the mass balance equations dynamically, and to assemble time variable information for forcing functions is, in our opinion, entirely justified.

REFERENCES

Allender, J. H. and Green, A. W. 1976. Results from a numerical model for simulating circulation patterns and chlorinity distributions in Saginaw Bay. *J. Great Lakes Res.* 2(1):7-12.

Canale, R. P. and Squire, J. 1976. A Model for Total Phosphorus in Saginaw Bay. *J. Great Lakes Res.* 2(2): 364-373.

Richardson, W. L. 1974. Modeling Chloride Distribution in Saginaw Bay. In *Proc. Seventeenth Conf. Great Lakes Res.* 462-470.

_____. 1976. An Evaluation of the Transport Characteristics of Saginaw Bay Using a Mathematical Model of Chloride. In *Mathematical Modeling of Biochemical Processes in Aquatic Ecosystems*, ed. R. P. Canale, pp. 113-139. Ann Arbor Science Press.